

HYDROMORPHOLOGICAL ALTERATION OF A LARGE MEDITERRANEAN RIVER: RELATIVE ROLE OF HIGH AND LOW FLOWS ON THE EVOLUTION OF RIPARIAN FORESTS AND CHANNEL MORPHOLOGY

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ABSTRACT

This paper evaluates the causes and effects of the hydrogeomorphological alteration of the central reach of the Ebro River (NE Spain). The Ebro River is one of the largest Mediterranean rivers. In this reach, it develops a meandering planform in a wide floodplain. Geographic Information System (GIS) analyses of historic aerial photographs, analysis of hydrologic data and measurement of various indicators linked to the fluvial morphology and the structure and distribution of the riparian vegetation led to the establishment of the prevailing processes in the dynamics of this river.

Statistical analyses conducted on some of the main components of the flow regime, including floods, droughts and flow duration curves, showed a role for these components in river dynamics. Similarly, a thorough analysis of the evolution of the aforementioned indicators was performed to identify and measure the effects of the hydrological regulation of the river. These indicators were measured in 1927, 1956 and 2003 for a 106 km reach.

The geomorphic dynamics of the Ebro River in its central reach reflect a remarkable tendency for stabilization and rigidification of the channel. The active river corridor has largely been modified, primarily in the second half of the twentieth century. The corridor lost a huge portion of its width and extension, the channel suffered an intense narrowing and the natural mobility of the meander train decayed proportionally. The structure and distribution of the riparian vegetation were completely transformed. The riparian forest lost its original function, behaving as a linear corridor and was notably continuous and very close to the channel thalweg. The vegetation colonized most of the previously active channel, contributing to the loss of the natural dynamics of the river.

The hydrological analyses suggest that the large morphological modification of the river planform and the parallel alteration of the riparian forests are not to be seen as a consequence of a loss of the attributes of natural floods. On the contrary, these extreme hydrological events only generate slight alterations due to river regulation and are not capable of enhancing the aforementioned evolution. Nevertheless, a profound change in the attributes of the low (summer) flows was found. The modification of the low flows was studied through its relationship with the global evolution of the geomorphic indicators and the riparian forest indicators. The results show the relative role played by high and low flows in the evolution of the river dynamics. These results are used to propose a future scenario of ecohydrological management in the central reach of the Ebro River. This scenario is intended to improve its ecological status and recover, at least partially, its natural dynamics. Copyright © 2010 John Wiley & Sons, Ltd.

KEY WORDS: ecohydrology; fluvial geomorphology; regulation; riparian forests; low flows; Ebro river; meander dynamics

Received 25 September 2009; Revised 12 January 2010; Accepted 13 January 2010

INTRODUCTION

The paradigm of the natural flow regime (Poff *et al.*, 1997; Poff and Zimmerman, 2010), which is widely accepted (Postel & Richter, 2003; Tharme 2003), recognizes the vital role of the flow regime in sustaining fluvial ecosystems. River regulation may affect high flows (ordinary and extraordinary floods) and low (summer) flows. This

alteration commonly has effects on all the basic components of the flow regime (magnitude, frequency, duration, seasonality and rate of change). All of these components are associated with a range of biological and physical thresholds that determine the river dynamics and integrity and the presence of different flora and fauna communities. In the Mediterranean rivers, which are capable of hosting high biological diversity, this inter-dependence is especially remarkable (Magalhães *et al.*, 2002; Prenda *et al.*, 2006) due to the extreme variability of their flow regimes (Blondel and Aronson, 1999; Naiman *et al.*, 2008).

The hydrological variability of Mediterranean rivers and the lack of rainfall in their basins during the summer form

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